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Tradeable permits: their potential in the regulation of road transport externalities

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Abstract. In this paper the possibilities of using tradeable permits in the regulation of road transport externalities are explored. After discussing the theory of tradeable permits and some practical applications, we will identify a number of potentially promising applications of their usage for coping with road transport externalities. These include applications on the demand side (user oriented) and on the supply side (automobile and fuel industry).

1 Introduction

Increasing social and environmental stress caused by steadily growing levels of road transport has created an urgent need for efficient, effective, and yet socially feasible regulatory policies. Although the scale of the problems is probably recognized by policymakers at all relevant spatial levels, policy responses so far have hardly been able to curb trends to any significant extent. Most environmental gains due to more stringent standards and improved technologies are often to a considerable extent offset by increasing traffic volumes or will be offset in the near future when the cheaper and more easy to implement technological improvements are exhausted (Dodgson, 1997). Apart from environmental effects, peak-hour congestion in urban areas and on main arteries gets worse practically by the day.

A partial explanation for the apparent lack of adequate policy measures actually employed can be found in the trade-off between effectiveness and efficiency of regulation, on the one hand, and its social feasibility, on the other. In Verhoef et al (1996a) this trade-off is discussed for the regulation of road transport externalities. Roughly speaking, the most efficient and effective policies should be based on Pigouvian tax principles, providing optimal incentives to adjust road users' behaviour in all relevant respects; for instance, numbers of trips, length of trips, and environmental technologies used. However, such economic policies are probably the least popular instruments available, among the public at large and hence also among democratically elected politicians [see Emmerink et al (1995) and Verhoef et al (1996a; 1997) for further discussions on the social feasibility of various forms of road transport regulation]. However, besides principles based on the so-called variabilization of existing taxes on car ownership and usage, an important possible way of partially overcoming the rather limited social feasibility of economic instruments in the regulation of externalities is offered by schemes based upon the notion of tradeable (or marketable) permits.

In this paper we aim to identify the potential of tradeable permits in the regulation of road transport externalities. The following issues will be addressed. In section 2 a short overview is given of the theory of tradeable permits and of some of the applications that have so far been implemented. In section 3 a start is made with the identification of the potentials of tradeable permits in regulating road transport externalities. A short overview of the externalities of road transport is given, some

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peculiarities of the sector relevant for the design of regulatory policies are discussed, and potentially relevant actors are identified. On the basis of this discussion, we proceed to discuss some possibilities in more depth, namely applications on the demand side (that is, user-oriented schemes), in section 4, and applications on the supply side, namely the automobile and fuel industry, in section 5. Section 6 contains the conclusions.

2 Tradeable permits in theory and practice

2.1 Theory

Although the main ideas underlying the theory of tradeable permits actually originate from earlier writings Dales (1968) is the first economist, and the one cited most often, to propose environmental regulation by means of transferable property rights. Building on Coase's (1960) notion of lacking property rights as the fundamental reason for externalities to exist, Dales (1968) proposes the creation of transferable rights for the purpose of attaining water quality targets in a cost-effective manner. Montgomery (1972) has proved the cost-effectiveness of regulation by means of tradeable permits in a theoretical setting. In several places Tietenberg (1980; 1994) has offered discussions on all kinds of theoretical and practical details of tradeable permit systems. A number of basic characteristics of tradeable permits are worth mentioning here.

Tradeable permit schemes are designed to achieve a given environmental goal at the lowest possible social costs. Hence the policy target is defined in the quantity space and the associated consistent equilibrium price of the permits will be determined by the market through free trade in the permits. The choice for tradeable permits in the regulation of environmental externalities therefore more or less implies a deviation from the purist economic goal of achieving the Pareto optimal level of the externality. Instead of Pareto efficiency, the goal of cost-effectiveness—which is only a necessary, but not sufficient, condition for Pareto efficiency—becomes the central criterion. Only by coincidence would the target specified under a tradeable permit system coincide with the Pareto optimal level of the externality; however, in that case, tradeable permits would in theory offer an efficient means of achieving that level. In contrast, application of optimal Pigouvian taxation, based on marginal external cost rules, would render the optimal level of the externality, rather than its shadow price, as the outcome that would be determined by the (regulated) market.

A practical justification for specifying an environmental target, instead of leaving the determination of its optimal level to the market, is given by the many yet unresolved practical and methodological difficulties in the valuation of external costs, which is of course a prerequisite for the determination of optimal Pigouvian taxes. A second category of problems associated with the specification of optimal Pigouvian taxes is that their equilibrium levels depend on demand and cost structures in the relevant market(s), unless marginal external costs are constant. Without knowledge of these structures, the optimal fees cannot be specified beforehand but would have to be found through a process of trial and error. Furthermore, apart from purist economists, most people would be more concerned with achieving certain environmental targets per se than with the theoretical goal of Pareto optimality. It is presumably for this reason that Cropper and Oates (1992) see it as 'a major advantage' that, with tradeable permits, the regulator obtains direct control over the quantity of emissions.

Moreover it is in this respect noteworthy that the generality of the concept of Pareto optimality in the design of environmental policies has been questioned. In particular in the context of the goal of sustainable development, explicitly taking account of the interests of future generations, it is questionable whether—and even unlikely that—a completely consistent treatment of future needs in terms of intertemporal externalities

could ever be realized. The most obvious problems encountered in such approaches would be those concerning discount rates, consumer sovereignty, and uncertainty (Pezzey, 1993; Van den Bergh, 1996). Instead, in addition to allocative efficiency, the concept of sustainability seems to call for a scale dimension when environmental regulation is considered from an economic perspective (for instance, see Daly, 1989). A possible approach to the operationalization of this scale dimension has been proposed by Siebert (1982) and Opschoor (1992) who suggest application of the 'environmental utilization space' as a restriction on the extent to which a generation should be allowed to use natural resources. The specification of a set of upper bounds to a generation's allowable environmental claims could be based on ecological phenomena, such as carrying and regenerative capacities of ecosystems, and would be the domain of biology and ecology rather than economics. Clearly, once this viewpoint is accepted, regulatory schemes based on tradeable permits may indeed offer a cost-effective means of achieving the implied environmental targets.

In a static, partial, full information setting, optimal Pigouvian taxes and tradeable permit schemes can be shown to be equivalent in terms of allocative efficiency so long as the target of the latter is consistent with the optimal level of the externality. However, the properties of both systems may diverge as soon as a broader perspective is taken.

First, from a dynamic point of view, this is the case when it is assumed that sluggish policies prevail; that is, when the regulator does not respond immediately and perfectly to changing market conditions by appropriate adjustments of either the Pigouvian tax or the number of permits. For instance, the entry of new emitters would leave total emissions unaffected under a tradeable permits scheme whereas it leads to additional emissions in case of Pigouvian taxes. Which of these two possibilities is preferable depends of course on the policy goal chosen; that is, the attainment of a given environmental target versus Pareto optimality through consistent charging of marginal external costs. Second, in case of inflation, an attractive property of tradeable permits is that their price would adjust automatically whereas the real Pigouvian tax would then decrease. Third, with sluggish policies, Pigouvian taxes would give a greater incentive to use abatement technologies as soon as cheaper ones become available (see Tietenberg, 1994).

The impact of uncertainty upon the relative performance of Pigouvian taxes and tradeable permits has also received much attention in the literature (Adar and Griffin, 1976; Weitzman, 1974). Depending on the circumstances, in particular on the slopes of the various relevant benefit and cost curves, either charges or permits can be shown to be preferable when set under uncertain conditions. Although these are interesting and important matters, we will not repeat the arguments here (for more details, see Baumol and Oates, 1988, chapter 5; and Tietenberg, 1994, chapter 12).

A number of important issues in the design of tradeable permit systems have been outlined in Tietenberg (1980). Among these, we mention the following. First, a policy target has to be defined. This target can be specified in terms of overall emissions (EPS, emission permit system) or in terms of ambient standards (APS, ambient permit system). APS has the advantage of being related more closely to the damages caused but the disadvantage of having a less straightforward connection with each individual emitter's activities. From the viewpoint of the emitters EPS would therefore be easier to handle; with APS they would have to obtain permits for every 'receptor point' that is affected by their emissions. A disadvantage of EPS would be that it is generally not capable of achieving the least-cost solution as soon as marginal external costs vary over space and the externalities are not purely localized.

Second, the geographic domain of the policy targets and the area of applicability of the permits have to be determined. Within this area, it then has to be decided how many and which zones should be distinguished—where trade of permits is allowed within, not between, zones—in order to achieve certain standards for certain areas. All sorts of complexities can arise concerning these geographic characteristics, varying from the notion that border problems with emissions will usually be unavoidable to purely administrative and legislative difficulties. As regards the number of zones, an advantage of increasing the size of the zones is that this will increase the number of traders of permits, thus increasing the efficiency of the market. Furthermore it simplifies the administrative procedures. A disadvantage is that the likelihood of ‘hot spots’ occurring within zones may increase owing to possible concentrations of emitters within zones and that the policy becomes less capable of spatial differentiation.

A third important issue is the initial distribution of the permits. Two extreme positions that can be distinguished here are the ‘government pays’ principle and the ‘polluter pays’ principle. In the first case, permits would be distributed among sources according to existing emissions; in order to reduce overall emissions, the government would then subsequently have to buy back permits. In the other extreme, sources would have to buy permits in order to maintain their rights to emit; in that case, the scheme is actually very close to the alternative of Pigouvian taxation. Clearly, all sorts of intermediate positions are thinkable. Although the initial distribution of permits will in theory not affect the ultimate distribution (Montgomery, 1972), the equity impacts of the scheme are of course dependent largely on the initial distribution of permits. Indeed, it is the intermediate possibility of distributing the number of permits consistent with the target against a zero price that creates the possibility for the regulator to have a budget-neutral, and hence socially more acceptable, economic regulatory instrument. This is comparable with the Buchanan and Tullock (1975) type of argument explaining the preference of firms for standards over taxes: these generally leave them with larger profits and serve as a barrier for new entrants. In this paper, unless stated differently, we will assume implicitly such ‘grandfathering’ of permits.

Fourth, enforcement and monitoring has to be thought through carefully in order to guarantee that the programme is truly effective. In principle, appropriate combinations of the probability of being caught when emitting in excess of permits held and the associated fines should be sufficient to provide economic incentives preventing rational emitters from doing so.

A last important matter has to do with the degree of differentiation within the permit scheme. For some external effects, the actual place and time at which they are caused may be crucial factors for the resulting marginal external costs. This will, for instance, be the case for road traffic congestion. Therefore the degree of differentiation may be an important element for the ultimate cost-effectiveness of the scheme. Such differentiation could be achieved by the creation of temporarily or spatially differentiated permit markets between which no trade is possible (see also above). Alternatively, permits may be defined in units, where the number of units required to obtain the right to cause the externality—for instance, to emit a certain amount of pollutant—may vary over time and place. An advantage of this latter approach is that the market size for the permits is kept as large as possible, with a supposedly positive impact on allocative efficiency. Clearly, this requires the regulator to be able to weigh off the impacts of emissions at various locations and times. The same argument, however, applies to the setting of different standards for spatially or temporally separated emission markets.

2.2 Practice

The most well-known tradeable permit programme operating in practice is without doubt the US emissions trading policy. This programme has been discussed in, for instance, Hahn (1989) and Tietenberg (1994). The four main elements of this programme are: 'netting', involving plant-internal compensations of emissions; 'offsets', involving firm-internal or firm-external compensation through emission reductions by existing sources when starting a new source; 'bubbles', allowing existing sources to use emission reduction credits to satisfy their responsibilities; and 'banking', enabling firms to store emission reduction credits for subsequent use in the bubble, offset, or netting programme. According to Hahn (1989) the emissions trading programme has been successful in achieving emission reductions at significantly lower costs than would have occurred without the programme. However, these cost savings have resulted mainly through firm-internal trading. Some important programmes introduced recently are the Los Angeles 'smog trading' programme, involving the emissions of nitrogen oxides and sulphur oxides (Tietenberg, 1994); and the US 'acid rain control allowance' programme (OECD, 1994).

More specific to transport is the USA's lead trading programme designed to reduce lead from 1.1 grams per gallon for large refineries in 1982 to 0.1 grams per gallon for all refineries after five years. Banking of lead credits was allowed in 1985 and has been used extensively by firms since. After the termination of the programme in 1987 it has been evaluated as successful, which can be explained by two particular features: the amount of lead could be monitored easily, and the programme was implemented after agreement had been reached about the basic environmental goals. The envisaged cost savings of \$228 million have probably been exceeded because trading and banking activities have been somewhat higher than anticipated (Hahn, 1989).

Button (1993) mentions the USA's corporate average fuel economy standards (CAFE) programme, introduced in 1975, as another example of the application of tradeable permits in the transport sector. This programme was designed to make car manufacturers' fleets conform with certain standards: the harmonic average fuel consumption had to be 18 miles per gallon in 1978 and 27.5 miles per gallon in 1985. If the manufacturers were left to decide the exact strategies for conformance with these standards, they could improve the fuel efficiency of those types of vehicle where this was most economical.

Another application of tradeable permits in transport concerns tradeable taxi licences which are used in many cities to prevent excessive entrance of taxis in the market. In particular, because of the rather tight limits applied, the market prices for taxi permits in many Dutch cities now greatly exceed the institutional prices, and taxi vehicles often have to be used on a 24-hour basis to generate enough revenues to cover the cost of the licence. Because of these high licence fees, often of the order of or even exceeding the price of the vehicles, there has been an upward pressure on the (regulated) prices for taxi trips and the system has therefore often been criticized. An interesting dilemma has arisen now that the abandoning of these schemes in the Netherlands is being considered. In particular, it is not clear whether the local governments should buy back the permits at the institutional prices or at the prevailing market prices, which are often a multiple of the former.

In the context of aviation we note the trading that takes place in landing slots at some US airports and elsewhere as a means of making efficient use of scarce and congested runway capacity. In such schemes, the number of aircraft movements is limited, airlines are allocated slots but they may trade them (also see Morrison and Winston, 1989).⁽¹⁾

⁽¹⁾ We owe this example to an anonymous referee.

Finally, we note the Singapore vehicle quota scheme started in 1990 (see Koh and Lee, 1994; Phang, 1993). Although 'certificates of entitlement' (COEs) in each of the eight categories distinguished were initially transferable, stories about huge profits made by speculators resulted in the government deciding to terminate tradeability in most categories after October 1991, restricting the programme to a monthly sealed-bid tender auction. However, this did not reduce COE prices (Koh and Lee, 1994).

Regulatory programmes based on the notion of tradeable permits have indeed been used in practice. It is noteworthy though that such applications, apart from the netting-type 'plant renewal clause' in Germany, have all been outside Europe; notably in the USA, Canada, and Australia (OECD, 1994). Nevertheless even in Europe tradeable permits are receiving increasing attention and support as a means of regulating environmental externalities [for instance, see Klaassen (1995) for tradeable sulphur emission rights, and Nijkamp and Ursem (1995) for applications in the regulation of externalities in an urban context]. According to the evidence available, it seems that tradeable permit programmes indeed succeed in achieving considerable cost advantages in environmental policies by offering more flexibility to meet environmental standards. In order to assess the possibilities for further usage of tradeable permit schemes in road transport, we first discuss briefly the externalities generated by this sector.

3 External effects of road transport

Among all surface transport modes, road transport generates the largest external costs, both in an absolute sense and in a relative (per person-kilometre or per tonne-kilometre) sense (for example, see Kågesson, 1993; and Verhoef, 1994). There is a large variety in these externalities caused by road transport. An important distinction can be made between 'intrasectoral' external costs and (social or ecological) environmental external costs. The first include those externalities that road users impose upon each other, such as congestion. The latter are imposed mainly upon the rest of society, such as noise annoyance and air pollution. Another distinction can be drawn between effects that arise from actual transport activities, such as pollution, congestion, noise, and accidents; external costs that arise when vehicles are not in motion, such as parking externalities; and external costs that are related closely to the existence of infrastructure, such as visual annoyance.

Some external costs exhibit both intrasectoral and environmental properties. For instance, external accident costs are to a certain extent imposed upon fellow car users, partly upon people outside this population (the 'social' environmental incidence), and finally may have an ecological environmental incidence when transport of hazardous substances is involved. The second-order incidence of the externalities can occur at different scale levels. For example, congestion usually increases emissions per vehicle-kilometre but may at the same time reduce the number of fatalities (Shefer and Rietveld, 1994). The severeness of these external costs will to a large extent be sensitive to time and place but at least in a qualitative sense the above discussion indicates that road traffic indeed gives rise to a wide range of external costs. As compensating external benefits of road transport do not exist—the benefits are usually internal or pecuniary (Verhoef, 1994)—this indicates a clear case for restrictive regulation.

For a number of reasons, the regulation of road transport is even more complicated than that of other sectors. In the first place, as discussed above, the regulation of external costs of road transport is complex because of the sheer number of distinct externalities involved. Unless regulation takes place by means of Pigouvian taxation, in which case the various marginal external costs can be considered additively, this implies that, according to the 'Tinbergen rule' which states that the number of

instruments should be equal to the number of goals, a relatively large number of different instruments may be needed.

Second, to complicate matters the various external costs of road transport may often differ with respect to a number of dimensions. For instance, with respect to the time dimension, some effects are instantaneous, such as congestion or noise; some are pervasive but decaying, such as hydrocarbons; and some are rather permanent and/or cumulative, such as car wrecks, visual intrusion, severance and barrier effects, and CO₂ emissions. Likewise, the spatial incidence may vary from the local level for noise, congestion, and lead up to the global level for CO₂ emissions. Therefore, different externalities may require different policy responses, for instance, in terms of spatial coverage and coverage over time; and a satisfactory set of policy measures should have enough flexibility and be comprehensive enough to deal with these dimensions.

Third, contrary to the assumption made in most textbook models of environmental regulation, the external costs of road transport are generated by a large number of individuals who are by definition mobile. Besides the practical problems that may thus be encountered in terms of, for instance, monitoring and enforcement, this has some other far-reaching complications. First, it means that the social feasibility of regulation, which directly affects many individuals, is a very important issue (also see Verhoef et al, 1996a). Next it implies that physical command and control regulation, because of the heterogeneity among sources, may often be less efficient than economic regulation (also see Verhoef et al, 1995a). It is important to note here that, based on the discussion in the previous section, both problems suggest a clear case for tradeable permits. Clearly, however, owing to the large number of mobile sources, such schemes will for practical reasons usually have to be restricted to EPS-type schemes. Another complication due to the heterogeneity of road users is that so-called 'flat' or anonymous fees may not be first-best: as the marginal external costs may differ among road users depending on, for instance, trip length, time of driving, or vehicle technology, so do the optimal regulatory fees. This issue is discussed in Verhoef et al (1995b). For this reason, it is clear that a truly welfare-maximizing policy requires a rather sophisticated and flexible design. For the application of tradeable permits, it indicates a need for sufficient differentiation within the scheme(s).

Fourth, as the demand for transport is generally derived, regulation may often be frustrated by inelasticity of demand, particularly in the short run. In this respect, important success factors for regulatory policies on road transport are the flexibility in the underlying spatioeconomic systems at the urban, regional, national, and global scale levels, as well as the availability of alternatives such as different modes or tele-facilities.

Many policies to reduce external costs of road transport can be distinguished. In Verhoef et al (1996a) a distinction into three main categories is made, which may also be helpful in the context of the present paper. A first group of instruments relates to 'direct demand management policies' aimed primarily at reducing the overall demand for road transport, for instance, by means of pricing. These policies aim to achieve a favourable movement along the demand curve for road transport, thus leading to a lower level of overall external costs. A second group of instruments relates to the actual position of the demand curve. Such 'indirect demand management' is aimed at shifting the demand curve for road transport inwards by affecting factors underlying the derived demand for transport, such as the spatioeconomic organization at various scale levels but also working times (peak spreading) and the availability of alternative transport modes. The third main group of instruments are 'supply side oriented' and aim to shift the external cost curve downwards. For environmental externalities,

this usually involves the use of cleaner fuels or vehicle technologies; for congestion this might involve the supply of additional road capacity, in particular at bottlenecks.

In general, an efficient reduction in external costs will require simultaneous adaptations in each of these three policy fields. In the long run, and under the hypothetical assumption of otherwise perfectly functioning markets, a first-best policy of marginal external cost pricing would in theory provide the optimal incentives for such changes to materialize. Clearly, however, markets will often not function perfectly in reality and first-best external cost pricing will often not be a realistic policy option. In such cases, it becomes necessary to design a set of policy measures jointly covering the three main policy fields distinguished.

This is also the case for the various possible applications of tradeable permit programmes in the regulation of road transport externalities. It is in this respect relevant to make a distinction between the various groups of actors that can be the primary target groups for policies. For direct demand management, these are mainly the road users themselves. For supply-side-oriented policies, it is in particular the automobile and fuel industries that are the most logical target groups. In the following two sections, these two target groups will be dealt with. The third main policy field of indirect management seems a less fruitful area for the application of tradeable permit programmes. For these issues, it is more regulation through, for instance, spatio-economic policies, urban planning, and public transport supply that is relevant. Therefore this group of policy instruments will be discussed only briefly in the remainder of this paper, with the exception of section 4.3.3.

4 User-oriented tradeable permits schemes

In this section we consider a number of potential applications of tradeable permit schemes for road-user-oriented policies. Such policies may be envisaged in various forms. The main distinction drawn is between schemes directed toward vehicle ownership and those toward road usage.

4.1 Vehicle ownership permits

The classical practical example of vehicle ownership permits is without doubt the Singapore vehicle quota scheme (VQS). By its very nature, such a scheme affects car ownership more directly than it does car usage and therefore affects the external costs of road transport only in a rather crude distorted way. However, it is fair to stress here that this point is well recognized in Singapore. For instance, for the purpose of congestion reductions Singapore has its equally famous area licencing scheme. In addition, the government plans to introduce electronic road pricing in 1996 (Koh and Lee, 1994; Phang, 1993). The VQS scheme provides only a first limit to the demand for road transport, which would otherwise possibly exceed by far the capacity of the Singapore road network because of the extremely high population density of the city.

Nevertheless for the purpose of the present paper it is worth investigating the possibilities of such vehicle ownership schemes for the regulation of road transport externalities. Apart perhaps from parking externalities (the usage of public space, see section 4.3) and environmental impacts of both the construction of new vehicles and the disposal of worn-out ones, not many externalities of road transport are connected directly to car ownership. Instead these depend on car usage, which renders policies aimed at a reduction in car ownership too crude an instrument. Moreover, dependent on the question of how the permits are distributed initially, such a scheme may have unwarranted income distribution impacts. In particular, if permits are sold through bidding procedures, as in Singapore, it is likely that eventually those with lower incomes will be affected disproportionately in their mobility because they cannot afford

such 'entry fees' for the road system. From the viewpoint of fairness it seems preferable to keep everybody's options to road usage open but to focus on the extent to which people use these options by using their cars.

However, one exception can be made and this would require a certain degree of differentiation within the scheme. Most environmental externalities of road transport depend on the technical characteristics of vehicles. Tradeable permit schemes can be envisaged that stimulate environmental technological improvements and the purchase of cleaner and more energy-efficient cars. As tradeable permit schemes directed toward the actual emissions of cars may be difficult to apply in practice (see also section 4.2 below), these modified schemes could provide supplementary incentives to regulatory schemes directed towards car usage.

Rothengatter (1989, page 164) makes a first proposal in this direction by suggesting a vehicle class certification system, in which "... a motor vehicle would be allocated to an emission class, and the manufacturer would purchase an emission certificate for each vehicle which he would then sell on to the buyer of the vehicle. If the manufacturer makes his vehicles environmentally more acceptable, the certificates to be bought become cheaper. On the other hand, if a purchaser retrofits environmentally beneficial technologies he can exchange an expensive certificate for a cheaper one".

Under such a scheme, certificates are not yet tradeable, except for trade with the regulator. In addition, from a distributional point of view, this scheme lacks the advantage of reduced transfers to the regulator. It is, however, possible to make emission class certificates freely tradeable among vehicle owners. These certificates could then be defined in 'class units', so that owners of cleaner vehicles require fewer certificates than those owning less clean vehicles. The total number of certificates released would then have an impact both on the number of cars and on their 'environmental quality'. Therefore the scheme would provide simultaneous incentives to give up car ownership, to retrofit environmentally friendly technologies, and to purchase cleaner cars.

The regulator can always intervene either by buying or by selling certificates. For the initial distribution of these permits, the regulator may decide to 'grandfather' them according to existing car ownership, in which case the initial composition and size of the car fleet determines the overall size of the market, measured as the 'environmentally weighted car fleet' (EWCF). Should the regulator decide that this initial size is excessive, he or she may decide either to start buying back certificates immediately or to distribute the permits at a certain price, offering car owners the possibility to buy sufficient permits according to the class of their vehicle. In principle, this latter option would also initiate a first move towards a *ceteris paribus* smaller and environmentally more friendly car fleet, as 'marginal' initial owners especially of relatively heavily polluting cars would then decide not to buy the certificates and to dispose off their cars. In any case, the transfers from car owners to the regulator under an EWCF scheme are likely to be significantly smaller than under the scheme envisaged by Rothengatter (1989) because in the former case the permits are not sold.

As mentioned before, whether such an EWCF scheme is desirable depends partly on the design of the regulation of car usage, in particular on the question of whether that regulation does account for differences in emissions among cars. We will discuss this issue in the next section.

4.2 Tradeable permits in the regulation of road usage

Most external costs of road transport do not arise primarily from the possession of cars but from their more direct usage. Therefore it seems that policies aimed at reducing car usage or actually at reducing the resulting externalities should have priority

in the design of regulatory schemes for road transport. In this section we will discuss a number of possible schemes based on the notion of tradeable permits. The attractiveness of these schemes in the regulation of the various externalities will be evaluated in terms of their expected efficiency. However, it should be stressed at the outset that the attractiveness and efficiency of a certain scheme is dependent generally on the design of the overall policy package. In other words, a certain scheme may be desirable only if accompanied by a certain other scheme; or, conversely, a scheme may be undesirable or superfluous if another 'competing' scheme coexists.

For the assessment of the expected efficiency of the various schemes, we will use as a leading principle that the more the scheme differentiates, or at least lends itself to differentiation, in accordance with the various dimensions that determine the marginal external costs of road trips, the higher its efficiency. Table 1 gives a rough idea of these dimensions (also see Verhoef et al, 1995a). Although we are aware of the limited accuracy of table 1 we think it is helpful in assessing the expected efficiency of the various schemes discussed in the following sections.

Table 1. Dependence of various marginal external costs of road usage on various trip characteristics.

| Marginal external cost | Trip characteristic | | | |
|-----------------------------|---------------------|-----------------|-----------------|--------------|
| | mileage | time of driving | area of driving | vehicle used |
| Environmental externalities | *** | * | ** | *** |
| Noise | *** | ** | *** | *** |
| Safety | *** | ** | ** | * |
| Congestion | *** | *** | *** | * |

* relatively weak dependence, ** moderate dependence, *** relatively strong dependence.

As indicated in table 1 each of the marginal external costs depends on the length of trips. Environmental externalities due to emission of pollutants are in addition strongly dependent on the vehicle used and for some effects, like smog, on the area and perhaps time of driving. The same holds, and is somewhat more pronounced, for external noise costs. External safety costs of accidents may to some extent depend on the area and time of driving. An individual's contribution to congestion externalities is strongly dependent on the time and area of driving.

It should be noted that, apart from the four dimensions mentioned in table 1, driving style will often also be a very important element that makes actual external costs differ across individual road users. However, as the regulation of driving style is rather different from the regulation of the other dimensions mentioned, requiring instruments of control and appropriate fines and probabilities of being caught for contraventions, this element is not discussed in this paper.

It should also be mentioned that, although the EWCF scheme discussed above can be specified as a continuous target where the permits need not be specified according to some time dimension, many of the schemes to be discussed below will require specification regarding the time period in which they are valid (for instance, a certain year). Policy targets should then refer to the maximum mobility per year. However, to prevent severe discontinuities and speculation, and to make the system smoother some form of banking can often be allowed for, enabling road users to transfer a permit to the next period or of course to exchange it for a permit valid for the next period.

4.2.1 Tradeable driving day rights

A first possible scheme for the application of tradeable permits in the regulation of road transport is the tradeable driving day rights (TDDR) scheme, as proposed by Goddard (1997) for Mexico City. Such a scheme is likely to offer a more efficient solution to the problem of restricting car use than its purely quantitative counterpart, in which car users are simply confronted with interdictions to use their cars on certain days through, for instance, the odd or even numberplates schemes such as used in Athens, Greece. With TDDR, an overall policy target in terms of total vehicle-days is specified and car users can choose for themselves their driving days, generally leaving them with higher benefits of road usage than without tradeability, which in turn increases the overall efficiency of regulation.

Notwithstanding this advantage, there are a number of objections that can be held against TDDR schemes. Probably the most important of these has to do with the fact that the eventual impact on total mileage driven may be relatively small, as drivers will have a clear incentive to 'save' the trips they wish to make for the days they use their permits. As a consequence, road users suffer from reduced benefits because of unwarranted rescheduling of activities whereas the externalities resulting from these trips are not suppressed but rather merely shifted in time. This clearly implies an important inefficiency in regulation. Apart from that, during their driving days, road users will face no incentive to economize on mileage other than through the *private* costs of road usage, as opposed to the *social* costs. With reference to table 1 it will be clear that these are serious shortcomings for the efficiency of such schemes. Likewise, road users will face no additional direct incentive to avoid peak hours, which makes the scheme of only limited use for the regulation of congestion. Road users face no incentive to improve on the environmental characteristics of their vehicles.

Therefore TDDR schemes may still leave much to be desired in terms of efficiency of regulation, although the possible advantage for the regulation of area-dependent externalities should of course not be denied. It is in this respect fair to acknowledge that this spatial element is an important one for the case of Mexico City discussed by Goddard (1997). The first improvement that one can envisage is to specify an overall target of regulation in terms of vehicle mileage rather than the number of driving days. This observation brings us to the following scheme.

4.2.2 Tradeable vehicle-miles

Instead of restricting the number of days that road users are allowed to use their cars it may be more efficient to restrict the number of vehicle-miles they are allowed to drive through a tradeable vehicle-miles (TVM) scheme. Under such a scheme each individual would receive a certain number of personal vehicle-miles, which could subsequently be traded so as to accomplish an eventual distribution where only the vehicle-miles with the highest benefits would remain. The overall policy target, defined as total vehicle mileage, has a closer connection with the externalities caused than the number of days that a certain vehicle is actually used (also see table 1). A second advantage of TVM is that perverse welfare effects due to rescheduling of activities are avoided. Both elements suggest a higher efficiency of regulation than is possible with TDDR.

However, a potential disadvantage of TVM compared with TDDR is that it is less easy to apply the system in a spatially differentiated manner. In terms of control and enforcement, TVM may be cumbersome in practice, especially because there is no one-to-one correspondence between individuals and vehicles. Furthermore, like TDDR, TVM is likely to suffer from providing insufficient incentives to improve on vehicle technology. Some of these shortcomings could be avoided with the scheme discussed in the next section.

4.2.3 Tradeable fuel permits

Probably the most promising direction for the use of tradeable permits in the regulation of road transport externalities, particularly in environmental externalities, is through a system of tradeable fuel permits (TFP). In this case, the regulator should specify an overall target in terms of total fuel consumption by road transport.⁽²⁾ Many of the emissions of road transport are rather directly dependent on fuel consumption (CO₂ emissions even directly) and insofar as they are not they will in any case depend on mileage driven which is in turn related closely to fuel consumption. Like fuel taxation, TFP would provide simultaneous incentives to reduce car use and, in the long run, to purchase energy-efficient, and often cleaner, vehicles. The main difference between the two instruments is in terms of smaller income transfers with TFP, in particular if the permits are distributed for free.

Another advantage of TFP over TVM is the relatively simple monitoring and enforcement. So long as gasoline stations are allowed to sell fuel only to purchasers handing in a sufficient number of permits, this should be no major obstacle. For those road users who do not possess permits, such as foreigners or people who forget to carry them, ordinary fuel taxes could be used or permits could be offered for sale at the stations. In the former case, it is important to realize that this tax rate would create a natural upper limit for the permit prices in the market. If the market price of the permits reaches this level, then it is likely that the overall target will be exceeded. The distribution of permits at lower prices, or for free, is in that case nothing more than an *ex ante* redistribution of tax revenues that otherwise would have been generated through fuel taxation. To avoid such violations of the target, the tax should be set sufficiently high.

As is the case with fuel taxes, TFP schemes may suffer from border problems caused by transborder fuel purchases. The obvious 'solution' to this sort of problem is to implement the policy on an international scale; for instance, throughout the European Union. So long as this is not possible, one could think of practical solutions, where the number of permits required per litre of fuel purchased gradually reduces from the national standard at a distance of, say, 50 km from the border to, for instance, a quarter of this standard at the border. This would at least reduce perverse incentives of making additional vehicle-miles to purchase fuel abroad.

With reference to table 1 it seems that among the three schemes for direct demand management discussed so far TFP is likely to be the most efficient. However, this is especially the case for the regulation of nonlocalized and time-independent externalities. For the regulation of congestion and localized environmental externalities, both in particular relevant to urban areas, additional measures may be needed. In the next section one such possible supplementary scheme is discussed.

4.2.4 Tradeable road-pricing smart cards

Table 1 indicates that, for the regulation of congestion, one would actually have to use a scheme that allows for differentiation over time, space, and individual trip lengths. It is for this reason that electronic road pricing (ERP) is generally considered as the most efficient technical means of charging congestion fees. It is hard to envisage a charging system that could outperform ERP in terms of flexibility and efficiency. Most alternatives would be much cruder than ERP and this holds true for regulatory schemes based on tradeable permits. Nevertheless it seems possible to combine the

⁽²⁾ Alternatively it can even be envisaged that targets are set for the entire economy, in which case (fossil) energy permits should be tradeable between sectors. This would open the interesting option of achieving targets in a cost-effective manner not only within but also between sectors. It would take far too much time to discuss this option in great detail in this paper, but some advantages are evident.

attractive properties of ERP and tradeable permits. For this purpose we propose a scheme based on tradeable road-pricing smart cards (TRPS).

Originally, smart cards in the design of road-pricing schemes were proposed to overcome problems of privacy associated with automatic vehicle identification systems, such as used during the Hong Kong road-pricing experiment (Dawson and Catling, 1986). With a smart card system, road users would have a counter in their cars that ticks off a certain number of units from the smart card per mile driven, depending on the time and area of driving. Such a system guarantees sufficient anonymity, as road users will not receive a fully specified overview of their trips at the end of the month. Moreover, a smart card system has the psychological advantage of confronting road users more directly with the fee to be paid, which is not the case with *ex post* monthly bills.

Another possible advantage of such a system, relevant in the context of the present paper, is that it may be designed according to the principle of tradeable permits. As a matter of fact, there is nothing that would prevent the regulator from distributing a considerable number of smart cards, or units, for free. In this way, one of the major sources of social opposition against road pricing, namely its redistributive impacts (Verhoef et al, 1997), could to a considerable extent be overcome. Moreover, the regulator may decide to give the scheme a progressive element by favouring lower income groups in the distribution of the permits, to 'reward' people not owning cars by giving them smart cards which they can subsequently sell to car owners, and to make certain exemptions by, for instance, giving the disabled a relatively large number of units. Indeed the possibilities are practically unlimited.

Once in operation, the system could also be used to regulate other externalities that are dependent on the area of driving. In table 1 it is indicated that some environmental externalities, noise, and safety may vary over space. Insofar as these external costs are, at the margin, higher in urban areas than elsewhere, the 'base rate' of the counter could account for this. It is perhaps important to stress here that the smart cards could in principle be valid for all (urban) areas in the country, with the rates charged being different over time and place, so that the market for trading is sufficiently large and transparent.

It should be noted though that such a TRPS scheme does not leave the achievement of the cost-effective outcome entirely to the market. The price to be paid for road usage at a certain time and a certain place—in other words, the speed at which the counter ticks off the units—would still have to be determined by the regulator. This feature is, however, almost unavoidable because it is practically inconceivable how road users could bargain over road usage at each specific time and place. Indeed the main advantage of the scheme over ordinary road-pricing systems is that the limited social feasibility of road pricing may to a large extent be overcome. Moreover, as already pointed out in section 2.1, even in spatially and temporally separated permit markets the regulator has to weigh off the relative value of externalities in different markets to determine the total number of permits for each market.

A final point is that with the usage of TRPS the regulator may choose to create a hybrid form of tradeable permits and fees by offering additional smart cards for sale. The advantage of such a scheme would be that the impact of the scheme on total road usage is more flexible, which prevents the occurrence of the situation where the last units in a certain period would be sold at extremely high prices. In this case, the price charged by the regulator creates the upper limit for the market price. If this part of the scheme becomes effective, it is clear that the initial distribution of free smart cards is nothing more than an *ex ante* redistribution of road pricing revenues (also see section 4.2.3 above).

4.3 Tradeable parking permits

Parking policies have been put forward as a potentially promising instrument for regulating road transport externalities, in particular urban traffic congestion (Verhoef et al, 1995a). For the Netherlands, parking policies are one of the main pillars of road transport regulation; and, accordingly, parking policies are increasingly being implemented in many Dutch cities. In the context of the present paper it is worthwhile to consider to what extent tradeable permits could be used in the design of these policies. For this purpose, a distinction will be made into three target groups: residential parking, CBD parking, and employees parking.

4.3.1 Residential parking

Parking in residential areas of cities is connected only to a limited extent to actual car usage, insofar as parking by residents themselves is concerned. In fact, whereas parking by these groups has an obvious link with car ownership, it is probably inversely related to car usage conditioned on car ownership: car owners who decide to use public transport, for instance, to commute or to shop, will generally demand more parking hours in the neighbourhood of their residence. It is therefore questionable whether potential favourable impacts of stringent parking policies in neighbourhoods in terms of reduced car ownership would not be outweighed by perverse impacts on car usage, induced by *ceteris paribus* reduced parking fee differentials between residential and other areas.

Such effects need not occur when parking policies for residents are not designed to account for the number of parking hours in the residential area demanded but are specified in terms of, for instance, monthly permits. In that case, the policy would again only affect car ownership by residents in the area. However, given the crude link between car ownership and external costs, it is unlikely that such policies offer a very efficient means of regulating road transport externalities. In any case it seems that for this purpose the EWCF scheme discussed in section 4.1 is preferable.

A last consideration concerning neighbourhood parking policies for residents is that such policies are, implicitly or explicitly, to a considerable extent motivated not by their impacts on externalities of road transport but by the goal of revenue raising by local governments. In such cases it is of course even less attractive to replace parking charges for residents by tradeable permit schemes.

Apart from residents themselves, a second group of parkers in residential areas are visitors. The question then arises whether tradeable parking permits could be used for regulating road usage by this group. Even here this does not seem to be the case. The basic problem is that this group of potential visitors is very large whereas only a relatively small subset will actually visit the area. This renders tradeable parking permits for this group a rather irrelevant option, as the permit market is bound to suffer from imperfect information and nontransparency of the market.

All in all we conclude that, for parking in residential areas, tradeable parking permit schemes do not seem to offer a very attractive option for coping with external costs of road transport. It can, however, be envisaged that, in case of insufficient parking space for residents, tradeable parking space permits, for instance on a yearly basis, could be used to arrive at an efficient occupation of the limited parking space available for residents. An additional pricing scheme could then coexist, aimed at irregular visitors of the residential area.

4.3.2 CBD parking

For the regulation of road transport externalities in city centres, regulatory parking fees could in principle offer an interesting option. Especially in the case of sufficient spatial differentiation, such a policy could be used to reduce urban traffic congestion

and environmental externalities in a reasonably efficient way (Verhoef et al, 1995a). The question therefore arises whether such a system could also be based on the notion of tradeable permits.

Unfortunately, we have to be a bit sceptical about this possibility. In the first place, a simultaneous implementation with a TRPS scheme (discussed in section 4.2.4) does not seem to be very useful, as both policies would be directed at the same sort of externalities, whereas TRPS seems to be preferable on the grounds of efficiency owing to greater flexibility and lacks the problems of through traffic and private parking that may to a certain extent undermine the attractiveness of policies directed at public parking space. Second, the market of potential parkers is likely to suffer from imperfect information and nontransparency for the same reasons as discussed above for visitors parking in residential areas. Third, the organization of trade among parkers is further complicated because of the dynamic dimension in CBD parking, where the arrival and departure times of visitors would almost have to coincide to guarantee the possibility of trade, and differences in parking duration may cause further complexities. As in the previous section, the only possibility worth further investigation would require a distinction between regular visitors (employees) and irregular visitors, where for the former a system of tradeable parking permits for 'long parking' in the CBD could be developed and for the others a parking pricing system would coexist. This will undoubtedly raise all sorts of questions regarding the level of spatial segregation and associated 'border problems'. Hence, even in the case of CBD traffic, tradeable parking permits do not seem to offer a very promising option for regulating road usage in an efficient manner.

4.3.3 *Parking place permits for firms*

Notwithstanding the so far limited scope for tradeable parking permits in the regulation of road transport externalities, there is one particular form that may actually prove worthwhile. This form has to do with the provision of parking places by firms for their employees and visitors.

In the Netherlands, the so-called ABC policy is important in this respect. In short, it distinguishes between three types of locations for firms. Locations A have a high accessibility for public transport and therefore stringent parking norms (10–20 parking places per 100 employees for new firms, sometimes corrected for a relatively high ratio of visitors per employee, such as in case of shops or hospitals). These locations are often found in city centres. Locations B, often at public transport nodes at city edges, have a moderate accessibility both for cars and for public transport and therefore less stringent parking norms (20–40 parking places per 100 employees). Locations C are easily accessible by car and are often near highway exits. These locations have no parking norms. The aim of the policy, in the long run, is to get the 'right firm at the right location' with respect to the induced mobility.

This type of quantitative arrangements is of course very likely to suffer from inefficiencies due to differences in the marginal valuation of parking space by different firms. It is therefore conceivable that flexibility of the policy, where the norms are specified only for areas, and firms could trade the rights to supply parking spaces, may lead to a much more efficient distribution of parking places among firms in a certain area. This form of tradeable parking permit scheme would not suffer from the information and nontransparency problems mentioned above because there are only a limited number of well-identified traders, namely the firms. This concludes our discussion on user-oriented tradeable permit schemes. In the next section some supply-side-oriented schemes are discussed.

5 Supply-side-oriented tradeable permit schemes

For the design of supply-side-oriented tradeable permit schemes in the regulation of road transport externalities, two groups of relevant actors can be distinguished and will be considered below: the automobile industry (section 5.1); and the fuel industry (section 5.2).

5.1 Tradeable permits in the automobile industry

5.1.1 *Average environmental quality*

Notwithstanding its firm-internal nature, the US CAFE programme discussed in section 2.2 is a real-life example of a successful application of the idea of tradeable permits in the automobile industry. The principles underlying CAFE could of course be extended in various directions. Apart from the average efficiency of new cars, as in CAFE, one could think of standards for average emissions per vehicle-kilometre and average noise emissions of new vehicles. Policy targets could then be specified in terms of corporate average environmental quality (CAEQ) of new cars. Such standards should apply both to domestic producers of cars and for firms importing vehicles.

Although this principle may indeed provide firms with the possibility of achieving certain average environmental standards for the newly sold cars as efficiently as possible, it does not allow for trade between firms (Button, 1993). However, it is possible that suppliers of automobiles face different marginal costs of improving the environmental quality of the cars sold. In such cases, it may be more efficient to specify standards for sectoral average environmental quality (SAEQ). Under such a scheme, producers of automobiles are allowed to 'pool' their sales in order to satisfy the sectoral standards. In case of (strongly) diverging marginal costs of improving the environmental quality of new cars, suppliers may mutually benefit from such pooling, which will then reduce the total economic costs of achieving sectoral standards. It also provides incentives to produce or import cars that more than strictly satisfy the prevailing standards, as such suppliers may subsequently benefit from pooling their sales with suppliers that do not satisfy the standards. The policy thus provides relatively strong incentives for continuing research and development efforts in environmental technologies.

When dynamic paths for standards rather than fixed ones are specified, it should in principle also be possible to allow for 'banking', in which case firms supplying cars that are environmentally more friendly than strictly required could build up the right to sell cars exceeding more stringent standards in the future; or to sell such rights to other firms in the future. For this purpose, units should be defined that represent the extent to which a vehicle is cleaner than required and the total number of units obtained, or required in the future, is equal to the number of cars sold times the difference in units between the car and the standard.

A slightly different system of trade in the automobile industry could be designed if regulation is directed at minimum numbers, or shares in total sales, of 'zero-emission cars' that car suppliers have to sell. Such a system is in operation now in California. In this case, the policy can be made more flexible, and expected costs reduced, by allowing firms to pool their total sales in order to meet the targets.

A final remark in this section concerns uncertainty. Especially when firms pool their sales, it is likely that in some cases the pooled sales may eventually violate the average standards because of unforeseeable market circumstances. The same sort of problem may also occur within a firm. It is therefore important to design rules to cope with such situations. For instance, one could use as a principle that, so long as the firm(s) can demonstrate convincingly that their policies were based on reasonable expectations, they should not be punished for such violations. Alternatively, a scheme

could be envisaged where firms pooling their sales would have to obtain approval for their planned production and sales, which reduces the possibility of extreme violations of standards. However, the most economical solution to this problem would be to charge sufficiently high taxes on sales violating the average standards.

5.1.2 *Environmentally weighted car sales*

Apart from measures aimed at improving the average environmental quality of new cars, one could also think of designing policies that aim to improve simultaneously the environmental quality and reduce the total sales of these cars. Analogous to the EWCF scheme discussed in section 4.1, the volume and environmental quality of total car sales could be controlled simultaneously by designing a tradeable permit scheme that aims to satisfy a target in terms of maximum environmentally weighted car sales (EWCS) at the lowest possible cost. Suppliers would then have to possess a number of permits for each vehicle sold, with the exact number depending on the environmental quality (see section 4.1). Also here, banking could be used to allow for maximum intertemporal flexibility within the scheme.

It is clear that such a system would certainly interfere with the EWCF scheme, if it were implemented. The permit prices in both markets can be expected to behave *ceteris paribus* in opposite directions: if the standard in the EWCF market is set relatively tight it will drive up EWCF permit prices, thus reducing car sales, which will subsequently lead to lower EWCS permit prices. Although the two schemes are not entirely interchangeable—EWCS concerns only new cars whereas EWCF also affects the existing car fleet—there is a clear possibility of redundancy in policies when both schemes are used simultaneously.

Comparing the two systems, we find that an EWCF scheme seems preferable, first, because of the above-mentioned feature that it affects the existing fleet and provides incentives to replace older vehicles by new and cleaner ones. EWCS in contrast may actually slow down the adoption of cleaner technologies in the car fleet. As a matter of fact, EWCS is likely to suffer from conflicting subgoals, where, on the one hand, one would like to see more new and cleaner cars in the fleet but, on the other hand, one would like to restrict the car fleet to a reasonable size, for instance, because of congestion. As it covers both new and existing vehicles EWCF does not suffer from such dilemmas.

Second, EWCS may have unwarranted distributional impacts. As the permits are given to the car suppliers, they actually receive the economic rent associated with these permits. Such a system may lead to higher sale prices, simply because fewer cars will be sold and hence the suppliers could then charge the price equal to the willingness to pay of the new marginal car purchaser. Especially when suppliers cooperate, they may thus be able to cash in the value of this rent.

This phenomenon is illustrated in figure 1 (see over). For the sake of simplicity, this diagram ignores complexities of either only new cars or all cars being subject to the permit scheme under EWCS and EWCF, respectively. Instead, the figure compares tradeable permits for reducing total sales of new cars only, applied on the supply side versus the demand side. The curve D represents the demand for new cars, which is equal to the marginal benefits (B^m) curve. The curve S gives the supply and is equal to marginal costs (C^m). The free market outcome is given by a quantity Q^0 and price P^0 . Now let us assume that the target of total sales is set at Q^* . Irrespective of whether regulators try to reach this target by means of tradeable permits for the right to sell cars, on the supply side (denoted as scheme 1), or for the right to buy a car, on the demand side (denoted as scheme 2), in both cases they have to issue Q^* permits, which will have a value of t each, so that the shaded area represents the total value of the permits.

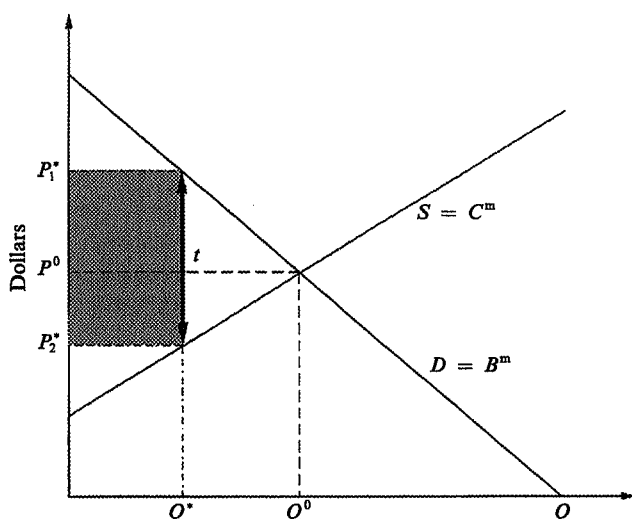


Figure 1. The incidence of the economic rent associated with the market value of tradeable permits.

Under price-taking behaviour on both sides of the market, the market price under scheme 1 will be P_1^* . Should the price be lower, the supplier of the marginal car will decide not to sell that car because the marginal production cost plus the price of the permit he or she needs to purchase then exceeds the price; in case he or she already possesses a permit, it would be more profitable to sell it than to use it and to sell a car for a price lower than P_1^* . Therefore the value of the tradeable permits, represented by the shaded area, will accrue entirely to the supply side of the market because of the difference between the market price, P_1^* , and the marginal production cost, P_2^* . This is not surprising because the suppliers receive the permits in the first place. Alternatively, under scheme 2 the equilibrium market price will be P_2^* , where potential buyers to the right-hand side of Q^* will find it more attractive to sell their permit and not purchase a car in case they receive a permit in the initial distribution or will not find it attractive to purchase a permit and buy a car in case they do not receive a permit. As the market price will be P_2^* in this case, it is clear that the value of the shaded area will remain on the demand side of the market.⁽³⁾ It is perhaps worth stressing that this simple analysis demonstrates that, in case of quantity regulation with tradeable permits, it is better to be on the 'regulated side' of the market. Because this may often be opposite to the primary intuition of the public, it is important to point out this fact clearly when proposing such policies.

Although the diagram does not reflect fully the difference between the EWCF and EWCS schemes, it demonstrates that the latter may lead to significant transfers from the consumers to the suppliers on the car market. Therefore, apart from the advantage that it affects the existing car fleet and new car sales, the EWCF scheme will often be considered more desirable for this reason as well. In particular, in contrast to the EWCS scheme it exhibits the attractive property of lower direct cost of regulation for the public at large, compared with regulatory taxation, *ceteris paribus* positively affecting the social feasibility, which was mentioned as one of the most important reasons for using this instrument in the first two sections of this paper.

⁽³⁾ As a third possible form of regulation, it can be mentioned here that under regulatory taxation at a rate t the value of the shaded area will accrue to the regulator.

Therefore for tradeable permit schemes directed at the suppliers of automobiles we conclude that the SAEQ scheme discussed in section 5.1.1 seems the most preferable option. This scheme affects most directly the marginal external cost curve of road transport—which is exactly the purpose of supply-side-oriented policies. Although the induced technological improvements are likely to increase the market prices of cars, it is important to stress that such price effects are likely to be smaller than under other forms of regulation on vehicle quality. In comparison with taxes, the SAEQ scheme causes no financial transfers from the industry to the regulator and may therefore keep prices relatively low; in comparison with pure standards, prices are likely to remain lower because achievements are made in a cost-effective manner. Therefore, the SAEQ scheme is likely to result in the socially most feasible way of improving the environmental quality of cars.

5.2 Tradeable permits in the fuel industry

After the more extensive discussion in the previous section, we can keep this section on applications of tradeable permits in the fuel industry very brief. For the fuel industry, one could think of various programmes that can be based on the same principles as used in the US lead trading programme. As already pointed out in the previous section, with this sort of SAEQ scheme one could arrive at a low-cost path for attaining certain environmental standards for fuel quality over a given number of years.

For the fuel industry, one could in addition broaden the scope to the regulation of sales volumes. Although the first objection raised in section 5.1.2 against such measures on the supply side does not hold for fuel, which is a nondurable consumption good, the second objection of induced income transfers from consumers to the suppliers of fuel negatively affecting the social feasibility of regulation does hold.

Therefore, even for the fuel industry, it seems that SAEQ schemes are the most promising application of tradeable permits for the regulation of road transport externalities.

6 Conclusion

In the previous sections, an exploratory assessment of the possibilities of using tradeable permits in the regulation of road transport externalities was given. Such regulatory schemes have the attractive property of yielding cost-effective outcomes in the realization of certain policy targets while offering the possibility of keeping the transfers from regulatees to the regulator at a minimum. For this reason, tradeable permits are likely to be more feasible socially than regulatory Pigouvian taxes. A number of possible applications were discussed and their main advantages and disadvantages are summarized in table 2 (see over). The most promising options are denoted by superscript b and will be summarized here by describing what appears to be the most attractive package of schemes.

Starting with user-oriented applications, it seems that for the regulation of non-localized and time-independent external costs of road transport (often environmental externalities) tradeable fuel permits (TFP) offer the most attractive option, providing simultaneous incentives to reduce mobility in the short run and to purchase environmentally friendly and energy efficient cars in the long run. Additional incentives to affect the size and composition of the car fleet in a favourable direction may be given through vehicle ownership permits, weighted for the environmental quality of the car (EWCF). For the regulation of time-dependent and localized externalities, often congestion and other externalities in urban areas, a supplementary system of tradeable road-pricing smart cards (TRPS) appears to combine the advantages of electronic road pricing in terms of efficiency and of tradeable permits in terms of social feasibility.

Table 2. Major advantages and disadvantages of various tradeable permit schemes for the regulation of road transport externalities.

| Programme | Major advantages | Major disadvantages or limitations |
|---|---|---|
| Supply-side-oriented | | |
| EWCS | controls both size and environmental quality of car sales | affects new cars only ^a benefits car and fuel manufacturers |
| CAEQ | cost-effective target meeting for fuel or car producing or importing firms | affects new cars only ^a firm-internal trading only |
| SAEQ ^b | as in CAEQ, but firm-external trading is also possible | affects new cars only ^a |
| User-oriented | | |
| EWCF ^b | controls both size and environmental quality of car fleet | not related to car usage (vehicle miles travelled, peak versus off-peak, etc) |
| TDDR | | rescheduling possible no incentive to avoid peaks or to change car technology |
| TVM | directly related to mileage | cumbersome control and enforcement no incentive to avoid peaks or to change car technology |
| TFP ^b | relatively simple control and enforcement | not suitable for controlling time-dependent and place-dependent externalities |
| TRPS ^b | controls both mobility and energy efficiency very flexible and hence suitable for controlling time-dependent and place-dependent externalities | may be perceived as complicated and should therefore be restricted to time-dependent and place-dependent externalities |
| Residential and CBD parking | | relatively weak relation with mobility possible nontransparency of market (for CBD); possible interference with TRPS spatial overflow |
| Supply of parking space by firms ^b | relatively transparent market cost-effective alternative to current ABC policy in the Netherlands | |

Note: CAEQ, corporate average environmental quality; EWCS, environmentally weighted car sales; EWCF, environmentally weighted car fleet; SAEQ, sectoral average environmental quality; TDDR, tradeable driving day rights; TFP, tradeable fuel permits; TRPS, tradeable road-pricing smart cards; TVM, tradeable vehicle-miles.

^a This argument is not relevant for applications in the fuel industry.

^b Most promising applications.

The applicability of tradeable parking permits was found to be limited, with the exception of permits used to achieve an efficient distribution of parking space over various firms in case of area-wide standards.

When specifying tradeable permit schemes on the supply side, it is important that these be restricted to sectoral average environmental quality (SAEQ). If these policies were also aimed at restricting quantities sold, the benefits of avoiding financial tax transfers to the regulator with tradeable permits instead of Pigouvian taxation would

accrue to the industry instead of to the public at large. This is likely to have a negative effect on the social feasibility of regulation.

In conclusion, there seems to be sufficient room for using tradeable permits in the regulation of road transport externalities. A full policy package may include TFP, TRPS, and perhaps EWCF on the demand side, and SAEQ schemes for the fuel and automobile industry. With this combination, simultaneous favourable adaptations on the demand and supply sides may be realized against relatively low social cost and with a relatively high social feasibility.

Clearly, a number of issues and potential obstacles still have to be explored further. These include, among others, the important question of how to restrict transaction costs to a minimum; the issue of border problems with, in particular, a TFP scheme; questions about the possibility of speculation and the possible consequences for the efficiency of the system; possible applications with an intersectoral dimension (energy); optimal target setting, in particular when jointly applying different schemes; and so on. These are just a number of the many possibilities for future research in this area.

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